UDK 677+687

ISSN 0040-2389

SAVEZ INŽENJERA I TEHNIČARA TEKSTILACA SRBIJE

1868 - 2017

tekstilna industrija

UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA

Naučni i stručni časopis tekstilne i odevne industrije
Scientific and professional journal of the Union of textile engineers and technicians of Serbia

Godina LXIV - Broj 1 (januar - mart) - 2017. godina - Beograd

VISOKA TEKSTILNA STRUKOVNA ŠKOLA ZA DIZAJN, TEHNOLOGIJU I MENADŽMENT

DTM

Starine Novaka 24
Beograd

Visoka tekstilna strukovna škola za dizajn tehnologiju i menadžment, kao sledbenik Više tehničke tekstilne škole osnovana je 30. juna 1958. godine. Odlukom Komisije za akreditaciju i proveru kvaliteta Republike Srbije od 03. maja 2007. godine Viša tehnička tekstilna škola u Beogradu je akreditovana pod nazivom Visoka tekstilna strukovna škola za dizajn, tehnologiju i menadžment. U novom ciklusu akreditacije, Škola je u januaru 2012. godine podnela zahtev za akreditaciju delom postojećih modernizovanih studijskih programa i delom novih studijskih programa koji su nastali kao logičan rezultat istraživanja potreba društva i tekstilne industrije.

Škola se kroz ispunjenje standarda za akreditaciju opredelila da našim studentima obezbedi strukovna znanja koja se mogu primeniti kako u teoriji, tako i u praksi. Naši studenti se praktično obučavaju u preduzećima tekstilne industrije, učestvuju na izložbama, revijama, konferencijama, objavljuju radove u časopisima, aktivno učestvuju u životu i radu Škole.

Škola uspešno sarađuje sa Privrednom komorom Srbije, Privrednom komorom Beograda, Savezom inženjera i tehničara, aktivni je član klastera modne industrije FACTS.
Škola je akreditovala sledeće studijske programe:

Studijski programi osnovnih strukovnih studija:

- Dizajn tekstila i odece; Tekstilno inženjerstvo; Menadžment u tekstilnoj industriji.

Studijski programi specijalističkih strukovnih studija:

- Odeća specijalne namene ; Modni menadžment.

011 32 32 430; 32 33 694
011 32 34 002
www.vtts.edu.rs
vtts@eunet.rs

SAVEZ INŽENJERA I TEHNIČARA TEKSTILACA SRBIJE
UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA

tekstilna industrija

1868 - 2017

Naučni i stručni časopis tekstilne industrije UDK 677+687 ISSN 0040-2389
Scientific and professional journal of the Union of textile engineers and technicians of Serbia

Godina LXIV • Broj 1 • Beograd 2017 • Strana 1-84 • Tiraž 100
Izdavač: SAVEZ INŽENJERA I TEHNIČARA TEKSTILACA SRBIJE
11000 Beograd, Kneza Miloša 7a/II, tel: 064 15 03 053
e-mail: casopistekstilnaindustrija@gmail.com
Tekući račun: 295-1201292-77 Srpska banka
Štampa: M studio, Stara Pazova

Predsednik Izdavačkog saveta: dr Goran Savanović
Redakcioni savet: Prof. dr Snežana Urošević, dr Gordana Čolović Prof. dr Dragan Đorđević, dr Ana Jelić-Aksentijević, dr Danijela Paunović, Stanko Kiš, dipl.ing
Glavni i odgovorni urednik: Prof. Dr Snežana Urošević
Lektor: Bojana Pejčić, M.Sc.
Tehnički urednici: ing. Aleksandar Sokolović, dr Mlađan Maksimović
Dizajn korica: ing. Aleksandar Sokolović

SADRŽAJ

U FINANSIRANJU ČASOPISA UČESTVOVALO MINISTARSTVO PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA REPUBLIKE SRBIJE

SAVEZ INŽENJERA I TEHNIČARA TEKSTILACA SRBIJE
UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA

tekstilna industrija

1868 - 2017 Naučni i stručni časopis tekstilne industrije UDK 677+687 ISSN 0040-2389
Scientific and professional journal of the Union of textile engineers and technicians of Serbia

Volume LXIV • Number 1 • Beograd 2017 • Page 1-84 • Printing 100
Publisher: Textile Engineers and Technicians Union of the Republic Serbia
Editoral offices: Serbia, 11000 Beograd, Kneza Miloša 7a/II, tel: 064 15 03 053
e-mail: casopistekstilnaindustrija@gmail.com

President of the Publishing Council: Goran Savanović, Ph.D.
Editorial Council: Snežana Urošević, Ph.D., Gordana Čolović, Ph.D., Dragan Đorđević, Ph.D.
Ana Jelić-Aksentijević, Ph.D., Danijela Paunović, Ph.D., Stanko Kiš, dipl.ing
Editor in Chief: Snežana Urošević, Ph.D
Translation: Bojana Pejčić M.Sc.
Technical Editors: Aleksandar Sokolović, ing, Mlađan Maksimović, Ph.D.
Cover design: Aleksandar Sokolović, ing.

CONTENT

THE FINANCING OF THE JOURNAL PARTICIPATION IN THE MINISTRY OF EDUCATION, SCIENSE AND TEHNOLOGICAL DEVELOPMENT

JOURNAL OF THE UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA
BEOGRAD, Kneza Miloša 7a/II, Tel/fax (011) 32 30 065
e-mail: casopistekstilnaindustrija@gmail.com

REČ UREDNIKA

Tekstilnu industriju karakteriše česta promena modnih tendencija, velika ponuda na globalnom i nacionalnom tržištu, ali ne i toliko velika tražnja. U takvim uslovima, u tekstilnom sektoru opstaju oni koji su u stanju da odgovore na zahteve potrošača. Proizvođači tekstila i odeće zato moraju da imaju osposobljenje i kompetentne zaposlene kako bi mogli da daju adekvatne i brze odgovore u zahtevima sa tržišta. Kao i u svakom razvojnom procesu, ključnu ulogu nose ljudski resursi, te oblast razvoja ljudskih resursa dobija prioritet kada je reč o proizvodnji tekstila i odeće.

U procesu proizvodnje tekstila i odeće, specifičnost je u tome što se mora objediniti sadejstvo umetnika i lica tehničkog profila. Zbog toga ljudski resursi predstavljaju komparativnu prednost svake organizacije tesktilne industrije koja pretenduje na ozbiljan nastup na domaćem ili na međunarodnom tržištu. Ljudski resursi treba da budu organizovani tako da oni stvaraju konkurentsku prednost svojoj organizaciji.

Posebno menadžeri, dizajneri i tekstilni inženjeri koji učestvuju u stvaranju odevnog predmeta moraju posedovati potrebna znanja, veštine i kompetencije koje će im pomoći da brzo reaguju na nastale promene u organizaciji kako bi pravovremenim odlukama obavili postavljene zadatke. Zbog toga je značajno da ljudski resursi u tekstilnoj industriji poseduju samopouzdanje, sposobnost brzog rešavanja problema, znanja i veštine u postavljanju međuljudskih odnosa i svest o ličnim prednostima i manama, zatim moraju imati dar i posedovati kreativnost, iskustva za sintezu mnoštva informacija da bi stvorili odevni proizvod kakav potrošači traže. Razvojem ljudskih resursa sa kombinacijom ovih komponenti kompetentnosti mogu dati rezultate koji se očekuju u uslovima sve većih zahteva tržišta odevnih predmeta.

Prof. dr Snežana Urošević

Naučni i stručni časopis „Tekstilna industrija“ u izdanju Saveza inženjera i tehničara tekstilaca Srbije već 63 godine objavljuje naučne i stručne radove, pruža raznovrsne informacije i obaveštenja zaposlenima u tekstilnoj industriji, te na svojstven način daje doprinos očuvanju i razvoju tekstilne industrije u Srbiji, ali i u svetu.

Koristim priliku da Vam se kao glavni i odgovorni urednik obratim i da Vam predložim saradnju i pozovem da pošaljete Vaše naučne ili stručne radove da ih publikujemo u našem časopisu, da reklamirate svoju organizaciju ili svoje proizvode na stranicama časopisa. Takođe, možete da se preplatite na časopis koji izlazi četiri puta godišnje.

Glavni i odgovorni urednik

Prof. dr Snežana Urošević

DETERMINATION OF WEIGHT LOSS OF COTTON FABRICS IN ENZYMATIC TREATMENT

Kiro Mojsov[1], Aco Janevski[1], Darko Andronikov[1], Stevan Gaber[2]

[1]Faculty of Technology, University of Stip, Republic of Macedonia
e-mail: kiro.mojsov@ugd.edu.mk; aco.janevski@ugd.edu.mk; darko.andronikov@ugd.edu.mk;
[2]Faculty of Economics, University "Goce Delčev" Štip, Republic of Macedonia,
e-mail: stevan.gaber@ugd.edu.mk.

Naučni rad
UDC: 677.027.625.3

Abstract: *The aim of the work was to measure the weight loss of scoured-bleached knitted cotton fabrics and enzymatic treatment. Cotton knitted fabrics were scoured-bleached using H_2O_2 at concentration (3 g/l) and with variable time (30 min and 60 min). It was observed that weight loss (%) was (2.97%) at concentration (3 g/l H_2O_2) using period of time (30 min) and increased (6.15%) using period of time (60 min). Enzymatic treatments were performed with Bio Polish B12 at different concentrations (0.3%, 0.6% and 1%) with variable time (30 min and 60 min). Also weight loss (%) was found lowest (1.72%) at 0.3% concentration of enzyme with lower time of treatment (30 min) and highest (4.23%) at 1.0% concentration of enzyme with higher time of treatment (60 min).*

Keywords: cotton fabrics, impurities, H_2O_2, cellulase, biopolishing, weight loss

ODREĐIVANJE GUBITKA TEŽINE PAMUČNIH TKANINA ENZIMATSKIM TRETMANOM

Apstrakt: *Cilj rada je bio da se izmeri gubitak težine od izvareno-beljenih pletenih pamučnih tkanina u enzimatski tretmanom. Pamučne pletene tkanine su izvareno-beljene koristeći 50% H_2O_2 pri koncentraciju (3 g/l) i sa promenjivim vremenom (30 min i 60 min). Primećeno je da je gubitak težine (%) bio (2.97%) pri koncentraciju (3 g/l H_2O_2) za vremenski period (30 min) i povećanom (6.15%) za vremenski period (60 min). Enzimatski tretmani su obavljeni sa Bio Polish B12 pri različitim koncentracijama (0.3%, 0.6% i 1%) sa promenljivim trajanjem (30 min i 60 min). Takođe je pronađen gubitak težine (%) najniži (1.72%) na 0.3% koncentracije enzima sa kraćim vremenom tretmana (30 min) i najviši (4.23%) na 1.0% koncentracije enzima sa dužim vremena tretmana (60 min).*

Ključne reči: *pamučne tkanine, nečistoća, H_2O_2, celulaza, biopoliranje, gubitak težine*

1. INTRODUCTION

Biofinishing is a relatively new concept of treating the fabrics with enzymes. Recent advances in biofinishing of cellulosic fabrics have led to multiple improvements of surface properties. The main objective of biofinishing is to upgrade the fabric by removing the protruding fibers. The conventional methods of removing the protruding fibers employ a burning-off process (singeing) or a chemical treatment. The conventional methods are temporary, potentially toxic, and fibers return to the surface after a few washings and form fuzz. The fuzz on the surface of the fabrics constitutes the major reason for customer dissatisfaction. However, by using enzymes in the finishing process, the protruding fibers can be permanently removed from the fabric thus eliminating the fuzz. The enzyme treatment not only keeps the

fabric looking new after repeated washings, but enhances feel, color, softness and drapeability which translates into a higher quality textile or apparel product [1, 2].

Hydrolytic treatment of cellulosic fabrics and garments with cellulases has become a common treatment step in textile processing [3]. Cellulase preparations consist of several different cellulolytic enzymes which act synergistically in hydrolysing cellulose to glucose [4]. This effect is used in finishing processes to improve the handle and drape, prevention of fuzz and pilling, removal of fibrils, and in colour protection and increase in lustre and brightness of fabrics or garments [5]. The variables in textile processing or finishing operations include: fibre and fabric types; enzyme formulations and their dosage; and machinery types with different loading capacities. All of these factors lead to unique properties in all processed fabrics, which may strongly influence the degradation rates observed in substrates.

Cotton fabric has several impurities such as fats and waxes, pectinous substances, proteinous matter, ash etc. Presence of fats and waxes in cotton fabric imparts poor water absorbency. In order to remove these impurities, scouring of cotton fabric is normally carried out with strong alkali at high temperature and for longer duration. Although, this treatment gives very good results, one of the problems is high loss in weight of cellulosic material. The total amount of impurities to be removed is less than 10% of the total weight [6]. On the other hand, bleaching removes any unwanted colour from the fibres. This process also eliminates any traces of other impurities remaining from the previous preparation steps [7]. In the enzymatic treatment, producers of textile enzymes recommend dosages of approximately 0.05 to 6% of cellulase preparation on garment weight [8]. Due to the un-optimized cellulase composition and high dosages, significant weight and strength losses can occur.

Cellulase enzymes are complex mixtures of three major types of enzymes namely, endo-1,4-β-D-glucanases (EG) (EC 3.2.1.4), which randomly cleave internal glucosidic bonds within an unbroken glucan chain in the most accessible parts of cellulose polymers and newly created non-reducing chain ends then, become the substrate for 1,4-β-D-glucan cellobiohydrolases (CBH) (EC 3.2.1.91), which cleave them into cellobioses. Hydrolysis of cellobioses into the glucose end product is completed by β-glucosidases (BG) or cellobiases (EC 3.2.1.21), which splits cellobiose units into soluble glucose monomers. Complete hydrolysis of native celluloses, largely, depends on the combined actions of these three component enzymes. However, in total crude cellulases, endoglucanases (EG), cellobiohydrolases (CBH) and cellobiases are present in non-uniform compositions.

Biopolishing of cotton fabrics carried out, either before or after the dyeing process, has an influential role on dyeability of the fabrics. Bulky dye molecules used in cotton fabrics react only in the accessible regions of fibres, which are, also major parts of the substrates for enzyme hydrolysis during biopolishing. Cellulase pretreatment enhances penetration of alkali during scouring and increases the alkaline degradation of seed fragments in the subsequent process [9]. Disaggregating cellulose molecules and development of newer regions leads to improvement in dyeability though in some cases dyeability decreases with hydrolysis initially, due to decrease in already available accessible regions by the endo component. Presence of various components in the total cellulases plays a dominating role in altering surface morphology of the fibres [10]. Combination of biopolishing with shearing, singeing, considerably reduces the surface defects [11].

A linear relationship exists between depilling and weight losses for total cellulase and endo-rich cellulase [12]. EG and EG-rich cellulases exhibit better pilling rating at lower weight losses compared to other components of cellulases. For knitted fabrics, a weight loss of about 1-2% appears to be enough to realise a remarkable reduction in pilling tendency while woven fabrics shows no significant pilling reduction till 8-9% weight loss. Slow kinetics of enzymatic degradation of crystalline cotton celluloses allows handle of the fabrics to be improved without excessively damaging the fabrics [13]. Actual thickness of fabrics reduces with biopolishing, while the apparent thickness appears to increase with mechanical actions that lead to fibrillations [14]. Hydrolysis of cellulose molecules in different regions of the cotton fibres also alters the dimensional stability of the fabrics [15].

In case of high concentration of H_2O_2 or enzyme in the pretreatment processes, chemical cost will be increased. Again, if the weight loss is less than the standard mentioned, then impurities will remain in the substrate which will create absorbency problem during the combined process. Light bio-polishing may not be effective enough to remove fuzz and the presence of fuzz leads to fabric problems in wear, notably pilling and a frosted appearance, which causes an apparent

loss of colour [8]. Moreover, heavy bio-polishing will degrade cellulose causing excessive weight loss.

2. EXPERIMENTAL PART

2.1. Materials

- Fabrics: 100% knited cotton fabric,170 GSM (gram per square meter)
- Enzyme: cellulase **Bio Polish B12** from Multichemi Exports Ltd, Sri Lanka. Liquid preparation and produced by submerged fermentation of a non pathogenic microorganism. Process Parameters: Temperature/ 52-57°C; pH/ 4.5-5.5; Time/ 30-60 min; Dosage/ 0.25%-0.75%.
- Chemicals: Wetting and detergent (Imerol PCLF), Sequestering agent (Sirrix 2UD), Stabilizer (Stabilizer SOF), Sodium Hydroxide, Hydrogen peroxide 50%, Acetic acid, Peroxide killer (Bactosol ARL) from Clariant, Switzerland.

2.2. Treatment methods

Combined scouring-bleaching of cotton fabrics. In the combined scouring-bleaching of cotton fabrics, the scouring process is accelerated in the presence of H_2O_2 and less time is generally required to achieve good absorbency of the material. H_2O_2 is a powerful oxidizing agent that rapidly destroys the natural colouring matters present in cotton without undue oxidative damage to the fibres. Full use of the stabilizing properties of natural cotton impurities minimizes peroxide consumption during bleaching. High alkalinity at elevated temperatures produces efficient scouring action. Bleaching and leveling residual waxes are also affected in this process.

Recipe of combined scouring-bleaching of cotton fabrics: Treated the fabric with 1 g/l Imerol PCLF; 1 g/l Sirrix 2UD; 0.8 g/l Stabilizer SOF; 2.5 g/l Sodium Hydroxide; 3 g/l Hydrogen peroxide 50% at 98°C and with variable time (30 min and 60 min), after hot wash , neutral the fabric and treated with 0.2 g/l Bactosol ARL at 40°C for 10 min, wash.

Enzymatic treatment of cotton fabrics. Cellulase is a complex natural mixture of different components, which work synergistically to degrade cellulose to glucose. Knitted fabric in circular form is very difficult to singeing. But the surface of the fabric can easily be cleaned by bio-polishing process. The main advantage of bio-polishing is the prevention of pilling. The surface modification of cellulosic fabrics confers cooler and softer feel, brighter luminous color using cellulases. Biopolishing is getting tremendous popularity due to its effectiveness and process simplicity. The enzyme activities increase with temperature, but above a particular temperature the thermal agitation disrupts the tertiary structure of enzymes. Acid cellulases exhibit the greatest activity generally in the pH range of 4.5-5.5 at 45-55°C, whereas neutral cellulases require a pH 5.5-8.0 at 50-60°C. Generally a prolonged treatment time, excessive cellulase dosage and vigorous agitation may increase the fibre loss significantly.

Recipe of enzyme treatment of cotton fabrics: Enzymatic treatments were performed with Bio Polish B12 at different concentrations (0.3%, 0.6% and 1% o.w.f.) with variable time (30 min and 60 min). Acetic acid (100%): 0.5 g/l; Temperature: 52-57°C; pH/ 4.5-5.5; Hot wash: 90°C for 10 min.

The treated fabric samples (both for scoured-bleached and enzyme washed samples), after washing, were dried at 100°C for 2 h and conditioned properly before weight measurement.

2.3. Analytical methods

Prior to the measurements, samples were conditioned for 24 h at 20°C and 65% relative humidity.

Weight loss – The weight loss was determined by weighing the fabric samples before and after treatment and was expressed in percent. Assays were performed in duplicate. The weight loss of each sample was calculated as follows:

$$\text{Weight loss (\%)} = (W_1 - W_2)/W_1 \times 100$$

where W_1: the dry weight of sample before treatment and W_2: the dry weight of sample after treatment.

3. RESULTS AND DISCUSSION

3.1. Effect of combined scouring-bleaching treatment on Weight loss of cotton fabrics

The results on weight loss of knitted cotton fabrics in combined scouring-bleaching treatment are presented in *Table 1*.

Table 1. *Weight loss of the knitted cotton fabrics in combined scouring-bleaching treatment*

50% H_2O_2, g/l	Time, min	Weight of fabric before treatment, g	Weight of fabric after treatment, g	Weight loss of fabric, g	Weight loss of fabric, %
3	30	21.15	20.51	0.64	2.97
3	60	24.56	23.05	1.51	6.15

It is seen that the weight loss increased gradually with increasing time of pretreatment. Table 1 shows that that weight loss (%) was (2.97%) at concentration (3 g/l H_2O_2) using period of time (30 min) and increased (6.15%) using period of time (60 min).

3.2. Effect of enzyme treatment on Weight loss of cotton fabrics

The results on weight loss of cotton fabrics in enzyme treatment found at different concentrations and different time are presented in *Table 2*.

4. CONCLUSIONS

Biopolishing of cotton fabrics offers unmatched results that can otherwise be achieved using chemical finishes. Effective enzyme treatment, which depended on fiber content and treatment level, resulted in progressive weight loss. Assays were used to determine the amount of cellulose fiber loss. Weight loss of cotton knitted fabric is directly related to the relevant process loss during the wet processing. For higher production it is necessary to control the fabric from excessive weight loss in knit processing. This can be achieved by following all the parameters of production accurately

Table 2. *Weight loss of the knitted cotton fabrics in enzymatic treatment*

Enzyme conc., %	Time, min	Weight of fabric before treatment, g	Weight of fabric after treatment, g	Weight loss of fabric, g	Weight loss of fabric, %
0.3	30	20.51	20.16	0.35	1.72
0.3	60	23.05	22.55	0.50	2.17
0.6	30	21.23	20.62	0.61	2.91
0.6	60	20.57	19.85	0.72	3.48
1	30	21.89	21.04	0.85	3.89
1	60	22.18	21.24	0.94	4.23

Here it is seen from our experiment that the weight loss% increased proportionally with the amount of enzyme used for the same period of time and also with the time period for the same amount of enzyme. *Table 2* shows that weight loss (%) was found lowest (1.72%) at 0.3% concentration of enzyme with lower time of treatment (30 min) and highest (4.23%) at 1 % concentration of enzyme with higher time of treatment (60 min).

and by minimizing process losses. The test results revealed that weight loss in knitted fabrics in combined scouring-bleaching and enzyme treatment was less at the lower concentration and short period of time but increased with the increasing of concentration and time.

REFERENCES

[1] Hemmpel, W. H., *The Surface Modification of Woven and Knitted Cellulosic Fibre Fabrics by Enzymatic Degradation.* International Textile Bulletin Dyeing /Printing/ Finishing, 37(3), 5-14 (1991).

[2] Schubel, P. *Cellulase.* Textile Industries Dyegest-SA, 9(11), 4-5 (1990).

[3] Gübitz, G. M., Cavaco-Paulo, A., *Biotechnology in the textile industry-perspectives for the new millennium*. Journal of Biotechnology 89(2-3), 89-90 (2001).

[4] Wood, T. M., *Fungual Cellulases.* Biosynthesis and Biodegradation of Cellulose. P. J. Weimer, Haigler, Candace H.,. Marcel Dekker, New York, 1991, pp. 491-533.

[5] Kumar, A., Purtell, C., Lepola, M., *Enzymatic Treatment of Man-made Cellulosic Fabrics.* Textile Chemist and Colorist 26(10), 25-28 (1994).

[6] Choudhury, A. K. R., *Textile Preparation and Dyeing.* Special Indian edn, p. 149-150, 168, 185, 285, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2006, pp. 149-150.

[7] Broadbent, A. D., *Basic Principles of Textile Coloration*. Society of Dyers and Colourists, West Yorkshire, 2001, pp. 30-31.

[8] Heikinheimo, L., *Trichoderma reesei cellulases in processing of cotton*. VTT publications, Finland, 2002, pp. 28-29.

[9] Li, S., Jin, D. J., *Use of enzymes in dyeing and finishing*. Textile Asia, 34, 52-55 (2003).

[10] Obturk, H. B., Bechtold, T., *Splitting tendency of cellulosic fibres - part III tendency of viscose and modal fibres.* Cellulose, 15, 101–109 (2008).

[11] Zadhoush, A., Khoddami, A., Aghakhani, M., *The influence of enzymatic hydrolysis of cellulosic substrates on the final quality of coated fabrics.* Journal of Industrial Textiles, 30(3), 211–221 (2001).

[12] Raje, C. R., Gurjar, M., Kawlekar, S. R., *Finishing of cotton fabrics with cellulase enzymes.* Indian Textile Journal, 112, 37–41 (2001).

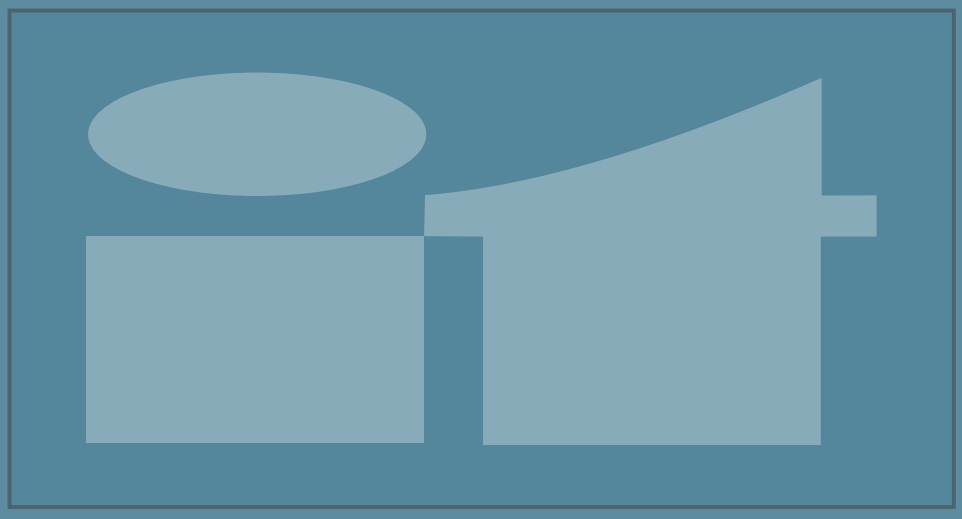
[13] Radhakrishnaiah, P., He, J., Cook, F. L., Diller, G. B., *Hand related mechanical behaviour of enzyme treated yarn, part I-role of spinning system*. Textile Research Journal, 75, 265–273 (2005).

[14] Almeida, L., Paulo, A. C., *Softening of cotton by enzymatic hydrolysis.* Melliand English, 74, 404–407 (1993).

[15] Cortez, J. M., Ellis, J., Bishop, D. P., *Using cellulases to improve the dimensional stability of cellulosic fabrics.* Textile Research Journal, 72, 673–680 (2002).

Rad primljen: 5.01.2017.

Rad prihvaćen: 2.02.2017.



TEKSTILNA INDUSTRIJA
Naučni i stručni časopis tekstilne i odevne industrije
Uredništvo: Kneza Miloša 7a/II, 11000 Beograd, Srbija, casopistekstilnaindustrija@gmail.com